Mr. Milton Whitney on so-called capillary water, it has seemed to me that the following explanation is plausible:

During clear, spring nights the ground a few inches below the surface retains the warmth of the preceding sunshiny day; by reason of this any moisture that may be there present is preserved as liquid water and works its way upward to the atmosphere either as vapor between the gravel grains, or as a thin film of water inclosing each grain and traveling from one to the next up to the very surface itself by capillary action. The films which would inclose the grains of the uppermost layer of gravel are apt to be quickly evaporated, but the films inclosing the grains immediately below that layer are protected from the wind and from diffusion into the dry air above. No sooner have the upper surfaces of the uppermost grains cooled by radiation below the temperature of their lower sides than there begins a process of conduction of heat upward through the body of each grain of gravel. Very soon moisture condenses as a liquid film on the cooling lower side of each grain, and soon afterwards on the upper side of the grain of gravel immediately below it, and so on gradually, as night advances, for a considerable distance downward. When now the uppermost grain has cooled below the freezing point then the next thing that happens is that on its lower surface its thin film of water freezes, and this implies that the water shall freeze last at those points where the upper grain comes in contact with the next lower grains because those points receive a little heat by conduction from below. Thus, at these points the frozen films protrude downward, and the projecting knobs may be considered as minute circles of ice formed in the watery films inclosing the lower grains while the rest of each such film still remains liquid.

Now, liquid water has a great surface tension, while ice has none, and the watery film inclosing any lower grain will almost instantaneously press in under and lift up the little speck of ice that has formed at the point of contact. The loss of heat by radiation from the upper grain continues steadily, and a steady process of conduction of heat goes on from the water of the lower film through the ice crystal at the point of contact up to the upper grain. Hence, there is a correspondingly steady formation of ice at the points of contact, and a continued renewal of the lifting process takes place until, in the morning, we find the upper grains, and even large pebbles, raised up several inches on the tops of tall columns of ice.

Will not some one devise a miniature repetition of this process in the physical laboratory? Let a small vessel be supported by three rounded metallic knobs resting on surfaces which are covered with thin films of water. The vessel should not be so heavy as to force out the films of water, and the surfaces of contact should not be so large that the circular areas have too large radii. The constricting power of a circular hole in a thin film increases inversely as the radius of the hole. A freezing mixture within the vessel should by conduction send down enough cold to produce ice at the points of support, and yet not enough to rapidly freeze any large portion of the film of water. The success of the experiment and of the natural formation of tall columns of ice must depend upon the radii of the frozen circular films at the points of contact and on the rate at which the heat that is absorbed from the lower film, is conducted through the ice and lost by radiation. The delicate adjustment of conditions that will bring this about makes this formation a very interesting physical problem.

When the outer air is frosty, while the sap is pressing up the body of the tree, a thin film of moisture may possibly be supplied from within as fast as the outer film at the surface of a crack may be frozen and lifted, and may thus form the exudations from the trees described by Doctor Leconte and also observed by myself and others.

This explanation of the growth of hollow columns of ice in gravelly soil, applies with slight changes to the hollow stems and plates of snow crystals. The whole subject of the growth of crystalline forms needs elucidation.

The very interesting investigations of Mr. Bentley on snow and frost crystals remind us of the following article copied from the Report of the British Association for 1858, part 2, pp. 40–41:

ON A FRESH FORM OF CRYSTALLIZATION WHICH TAKES PLACE IN THE PARTICLES OF FALLEN SNOW UNDER INTENSE COLD. BY J. WOLLEY, M. A.

In passing a winter in Lapland, it is impossible, whether in observing the tracks of animals, or merely considering day by day the condition of the roads for sledging, or of the snow for the use of snow-skates, not to be struck by the very variable character of the snow, partly caused by winds and fresh falls, partly by the condition of the rime or hoar frost upon the surface, but mainly, as it is soon found, by an alteration in the character of the mass of fallen snow.

In Lapland, as elsewhere, the snow as it falls is of several kinds. But whatever its character, it at first lies more or less lightly on the ground and if the weather is still and not very cold, it may so remain for days; but if the cold increases, the snow rapidly sinks; it becomes at first like sand, is crisp to the tread, bears the smaller animals, and soon becomes suitable for the skidor or snow-skates. When the cold has continued, probably many degrees below zero of Fahrenheit, for two or three weeks, not necessarily consecutive (the phenomena are more especially to be observed in the cold months of January and February), the snow beneath the surface is found to be made up of large pieces of a quarter or a third of an inch in diameter, glittering in the sunshine, clear, heavy, highly moveable upon one another, and seen upon even a hasty examination to be of a beautiful crystalline structure. On a closer inspection, they are found to be somewhat irregular in shape, with the outline of more or less complete hexagons with sides of unequal lengths; they are formed around nuclei by no means placed centrally, often quite where one side of the hexagon should be; and they grow in layers of bars one outside the other, often larger in section, as well as longer, as they recede from the nucleus; these bars (learned gentlemen will excuse me for not describing a crystal more properly) are free from one another, except at the angles; those of each layer lie in one plane, often not the same as the layer which preceded them lies in. At the angles are usually small crystalline projections, rising apparently perpendicular to the general surface of the crystal. These crystals are broken with a slight force; and many of those where the snow has been crushed have lost their nuclear portion, but retain the true hexagonal form.

Snow, in the condition of which I hope to have given at least some faint notion, is called *hieta lumi*, or "sand-snow", in the Finnish language. It yields more water, and hence, even when it is covered by more recent snow, the Laps take the trouble of digging down to it to fill their kettles with. These primitive people also use it in its dry state for washing or cleansing their clothes. After first exposing to the external cold for some hours the dresses they wish to purify, for reasons which I need not further explain, they beat them with sticks upon and under a heap of sand-snow.

When the winter covering of the ground is in this sandy condition (perhaps the moveable state of such shell-sand as that of John o'Groat's house may best represent it in one respect, and the appearance of a bag of clean crystals of salt give some idea of it in another), it is a great advantage to all the animals of the country in supporting their weight, and is a special comfort to the reindeer, from the facility with which they can remove it with their forefeet so as to get at their food beneath. Though intensely cold to a naked hand, it is much better than fresh snow for lying upon, as it does not yield too much to the weight of the body, and does not get into the nicks of the clothes, or melt in the fur. I may mention, that with only a thick pair of stockings on, one can walk for some little distance from a bivouac without risk of getting either wet or cold in the feet; and before a fire in the woods this snow never becomes sloppy, but seems to disappear only by evaporation, which greatly adds to the facilities of passing the long winter nights in a Lapland forest. The same thing is in a great measure true in the spring; the snow is very rarely to be found in that miserable state which marks the breaking up of a snow in England.

Concerning the formation of these crystals, I made experiments by burying in the snow at certain intervals of time, chip boxes, some empty and some containing fresh snow; I was prevented from fully carrying out and registering my observations, but I found that the changes went on in the boxes equally with the external snow, and in the boxes that contained nothing but air, but, nevertheless, were not so tightly closed as to prevent the transmission of air containing water in solution, crystals attaching themselves to the sides and top, but never to the floor, of the box, which crystals greatly resemble those in the snow; they were, however, often much longer, even to upwards of half an inch in length. In the course of my observations, I found that this sand-snow formed principally in open places, on lakes, bare soils, etc., growing less on spongy grounds, scarcely at all upon logs of wood or outbuildings.

TIDAL PHENOMENA.

Associated with the tides are many erroneous notions which appear from time to time in a variety of forms. Several of these constitute the essentials of an article by Mr. S. R. Elson, entitled "Tidal phenomena", which appeared in The Journal, Calcutta, India, for April 9, 1905. It is only because of the persistence of these and similar errors that notice is here taken of the article.

One of these is that the time required for the force of gravitation to traverse space may be considerable, and thus aid in explaining the fact that spring and neap tides do not occur simultaneously with the syzygies and quadratures. This idea is at least as old as Daniel Bernoulli's essay on tides; but that philosopher hardly deemed it worthy of serious consideration.

Another error consists in assuming that credence is still given by tidal authorities to the notion that a tide wave travels around the earth from east to west following the moon. While Mr. Elson justly condemns this notion, his explanation amounts to nothing save the admission of the undisputed fact that the tides are due to the disturbing force of the moon or sun.

He makes the unique assumption that, since a land mass may permanently raise the sea level along the shore above a height which it would otherwise occupy, the tides are due to the moon's tidal forces acting alternately with and against this constant attraction of the land mass upon the adjacent waters. How the permanent attraction of nearby-land masses comes into the periodic ebb and flow of the tide, is not made clear. This continental attraction is assumed to be lessened when the moon is on the meridian and to assume its undisturbed value when the moon is in the horizon. In other words, he imagines the vertical, rather than the horizontal, component of the moon's attraction to produce the tides, and that the vertical force vanishes when the moon is in the horizon; that these assumptions are errors, is too well known to require further notice.

Finally appeal is made to barometric readings for establishing the truth of this unique tidal hypothesis. He finds the greatest range of the barometer to occur soon after the time when the moon is near quadrature, and the least, soon after syzygy. This state of affairs may possibly exist at some places, because the atmospheric lunar tides are difficult to understand, and their small range, as measured by the barometer, renders them difficult to measure. But, according to observations made at Singapore, Batavia, and St. Helena the maximum height of the lunar fluctuation in the barometric pressure occurs when the moon is on the meridian or a little later. Now the large fluctuation in the barometer follows the period of the solar day, and, using the value given by Mr. Elson, the maximum height occurs at about 10 a. m. and 10 p. m. The maximum range should, therefore, occur on those days when the moon crosses the meridian at about 10 o'clock and not when she crosses the meridian at 6 or 7 o'clock, or on the days of neap tides.

On the whole, we think that Mr. Elson, who is well known in India, has not made his suggestions acceptable to those who have given much attention to the tides and tidal theories.—*R. A. H.*

METEOROLOGICAL COURSE AT WILLIAMS COLLEGE.

In the REVIEW for March, 1904, p. 517, we gave the first part of the syllabus of the course of lectures by Prof. Willis I. Milham, on meteorology, during the current year at Williams College. The rest of this syllabus will be equally helpful to those who are giving similar instruction at other colleges, and is published herewith from the manuscript that is given to the students as a synopsis of his method of treating the subject.—*C. A.*

VI.

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